EFFECT OF BIOCOMPOSTED COCOA SHELL AND JACK FRUIT PEEL WASTE ON CERTAIN CROP PLANTS AND SOIL FERTILITY

SYNOPSIS

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INTRODUCTION

Agricultural-based industries produced a vast quantity of residues every year. These residues are released into the surroundings with an outright disposal approach that can cause environmental pollution and threatening impacts on human and animal fitness. Most of the agro-commercial wastes are untreated and underutilized and it is disposed of both with the aid of burning, dumping, or unplanned landfilling (Bos and Hamelinck 2014). The rapidly growing population, along with improving economic growth has attracted significant investments in the food and agriculture industry, amounting to $75 billion in 2017. 5 million metric tonnes of biomass are produced annually from agriculture. Most of the wastes generated by using agro-based food industries are excessive in nutrients and can form breeding grounds for sickness-inflicting microbes if left unprocessed and inadequately handled (Bharathiraja *et al*., 2017). India generates yearly 350 million tonnes of Agricultural wastes (Mishra *et al*., 2016). Waste is an inevitable by-product that arises from various anthropogenic activities. Agricultural wastes have become an increasing concern in recent years, as they may cause significant environmental problems, however, they may use for several beneficial purposes. The need to implement strategies that safeguard natural and ecological resources, reduce financial outlays and foster social stability while maintaining high crop yields is one of today's agriculture's biggest issues. According to popular belief, organic soil amendments increase the number of earthworms in the soil by providing a nutrient-rich substrate where they can feed either on the organic materials themselves or on the microbes that colonize the organic materials (Chaudhuri *et al.,*2016).

Cocoa is a significant agricultural commodity and a cash product of great economic importance in the world (Afoakwa *et al.,* 2011). About 80% of cocoa fruit is discarded as residual biomass, including cocoa bean shells, cocoa pod husks and cocoa sweatings. Farmers routinely discard these residues during the initial cocoa bean processing steps, occupying vast areas, raising social and environmental concerns (Zulma *et al.,* 2019). Cocoa shells are one of the by-products of the chocolate industry that has great potential because of their composition. Cocoa shells often cannot be used directly in food production because they may contain components that are harmful to human health. Cocoa shells can carry mycotoxins, different microorganisms, polycyclic aromatic hydrocarbons, and heavy metals (Barisic *et al*., 2020). Cocoa shells can be used as manure combined with other organic materials to produce substrates for plant cultivation. This waste can be used to produce material for soil amendment since its addition to the soil as biofertilizers increases soil fertility and crop

productivity. Jackfruit is a popular fruit in India that consists of a fleshy edible bulb. Its peel is not edible, no commercial use and adds up to the world's agricultural waste (Delos *et al.*, 2018). Most of the jackfruit is harvested and processed for meat, the rest is the jackfruit peels, and fibers are discarded, which will affect environmental sanitation. The value of jackfruit is by taking advantage of nutrient ingredients in the peel and to blend into organic fertilizer (Tran *et al*., 2021). Maximum fruits get wasted due to unawareness, lack of post harvest era and gaps in supply chain structures. Jackfruit peel is considered to be an underutilized waste (Sundarraj and Rangaanthan 2017). Improper handling of both these wastes creates environmental problems like the proliferation of pests, diseases, air and water pollution also. Cocoa shells and Jack fruit peel waste do not degrade quickly due to the presence of large amounts of chemical constituents like lignin, cellulose, hemicellulose, pectin and calcium.

Bioconversion of Cocoa shell and Jack fruit peel waste can be decomposed by using the mushroom spawns (*Pleurotus eous* & *Pleurotus florida)* and earthworms (*Eudrilus eugeniae)*. It is generally considered to be a safe, effective and eco-friendly method. Both the mushroom spawn belongs to the family basidiomycetes. Basidiomycetes assume an essential part in nature by recycling starch through lignin degradation. The vermicompost contained desirable nutrients, plant growth hormones and a high level of soil enzymes (Chitrapriya *et al*., 2013). Due to the high price of fertilizers and the scarcity of organic manure, the recycling of organic wastes for boosting soil fertility has acquired relevance recently. Vermicomposts are nutrient and plant growth hormone-rich materials that resemble peat Earthworms and the bacteria in their stomach break down organic waste during the vermicomposting process to create a stable, mature product. Vermicomposting is a useful technique for turning organic waste into products that are favorable for the environment. (Bhat *et al*., 2017; Lim *et al*., 2016). Organic farming is an important factor in the successful cultivation of healthy plants. This method of farming can be explored as an eco-friendly and sustainable waste management approach. Organic farming consists of environmentally friendly raw materials that can be returned to soils as biofertilizers. We know that organic wastes are a rich source of macro and micronutrients. Besides it also improves the soil's Physico-chemical, biological condition and crop productivity.

Vigna unguiculata (L.) Walp. commonly known as Cowpea has its origin in Africa (Owade et al., 2020) and spread across Asia, North America, and South America. *Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc is one of the most popular and Yard long bean cosmopolitan vegetable crop grown in Kerala. The traditional vernaculars viz., Achingapayar,

Kurutholapayar, Vallipayar, Pathinettumaniyan, Asparagus bean, Chinese long bean etc., used to refer yard long bean indicate that Kerala is the land of this crop. It is a rich and inexpensive source of vegetable protein (Varghese and Celine 2015). It enriches soil fertility by fixing atmospheric nitrogen. *Clitoria ternatea* L. also known as Shankapushpi and Butterfly pea is one of the important medicinal plants used for boosting memory and improving intellect and also to cure mental illness. The plant originated from tropical Asia and distributed widely in South and Central America (Dhanraj *et al*., 2018). Above mentioned three plants are belonging to the family Fabaceae. *Amaranthus tricolor* L commonly known as Red amaranth is now widely grown as vegetables both in the tropic and sub-tropic areas of the world. It can be grown throughout the year and can be harvested in a very short time. The reddish-purple color is due to the presence of anthocyanin which is an antioxidant. It contains essential minerals such as K, Ca, Mg, Fe, and P which are useful for health. Keeping the above facts in mind, the present investigation is taken up to study biocomposting of Cocoa shell and Jack fruit peel waste and its impact on *Vigna unguiculata* (L.) Walp Var. Co (CP) 7 (Cowpea), *Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc Var.NS-621(Asparagus bean), *Clitoria ternatea* L. (Shankapushpi) and *Amaranthus tricolor* L Var. Arun. (Red amaranth)

OBJECTIVES

The study was formulated with the following objectives

- To prepare biocompost from Cocoa shells (*Theobroma cacao*) and Jack fruit peel (*Artocarpus heterophyllus* Lam.) wastes using *Pleurotus eous* and *Pleurotus florida* and *Eudrilus eugeniae.*
- To count and evaluate the microflora present in biocompost during the 30^{th},60^{th} and 90^{th} days.
- To analyze physico-chemical parameters of raw and biocomposted Cocoa shell (CSW) and Jack fruit peel waste (JFPW).
- To investigate the functional groups of raw and biocomposted Cocoa shell (CSW) and Jack fruit peel waste (JFPW) using fourier transform infrared spectroscopy (FT-IR)
- To assess scanning electron microscopy (SEM) of raw and composted Cocoa shell (CSW) and Jack fruit peel waste (JFPW).

- To evaluate the role of different biocomposted treatments on the growth and yield of *Vigna unguiculata* L Walp., *Vigna unguiculata* subsp.*sesquipedalis* (L.) Verdc, *Clitoria ternatea* L and *Amaranthus tricolor* L
- To determine the biometric characters of selected plants.
- To study the protein and carbohydrate content in leaves and seeds of selected plants.
- To evaluate the crude protein content in seeds of selected plants.
- To determine chlorophyll a, chlorophyll b and total chlorophyll content in leaves of selected plants.
- To determine the leghaemoglobin content in nodules of selected plants.
- To analyze the pre and post-harvesting soil.
- To study the antioxidant and antibacterial activity of the selected plants.
- To analyze the phytochemical constituents present in two medicinal plants (*Clitoria ternatea* L and *Amaranthus tricolor* L)
- To determine the Mineral composition of selected plant leaves.

METHODOLOGY (EXPERIMENTAL DESIGN)

The materials and methods of the study were discussed in the following four phases.

PHASE I

1. **Collection of agro-industrial wastes**
    - Collection of microorganism
    - Composting procedure
        - Preparation of Cocoa shell waste biocompost
        - Preparation Jack fruit peel waste biocompost
        - Preparation of vermicomposting trays
2. **Microbial population during 30^{th} ,60^{th} & 90^{th} days of biocomposting**
3. **Evaluation of compost maturity**

    a. Physical parameters: pH and electrical conductivity of the biocomposted materials were estimated by using a glass electrode and electrical conductivity bridge.

b. Chemical parameters:

1. Lignin (%)
2. Cellulose (%)
3. Organic carbon (%)
4. Total Nitrogen (%)
5. Total Phosphorus (%)
6. Total Potassium (%)
7. Calcium
8. Magnesium

6. **Fourier transform-infrared (FTIR) spectrum analysis**

7. **Scanning electron microscopy (SEM)**

PHASE II

Pot Culture Experiments

- Collection of seeds
- Application of biocomposting treatments (T_1,T_2,T_3,T_4,T_5,T_6,T_7&T_8)
- Analysis of biometric characters of plants
    1. Root length (cm)
    2. Shoot length (cm)
    3. Number of leaves
    4. Number of branches
    5. Number of nodules
    6. Number of flowers/plant
    7. Plant fresh weight (gm)
    8. Plant dry weight (gm)
- Evaluating the yield parameters of plants
    1. Number of pods plant
    2. Length of pod (cm)
    3. Weight of pod (g)
    4. Number of seeds/pod
    5. Weight of seeds/pod (g)
    6. Pod fresh weight (g)
    7. Pod dry weight (g)
    8. Root length (cm)

9. Shoot length (cm)
10. Number of leaves
11. Plant fresh weight (gm)
12. Plant dry weight (gm)

PHASE III

Biochemical Analysis

- Estimation of protein and carbohydrate content in leaves and seeds of different stages of plants.
- Estimation of chlorophyll a, chlorophyll b and total chlorophyll content in leaves.
- Estimation of leghaemoglobin content in root nodules.
- Estimation of crude protein content in seeds (Kjeldahl Method)
- Pre and Post-harvest soil sample analysis
    1. pH
    2. EC
    3. Available nitrogen
    4. Available phosphorus
    5. Available potassium

PHASE IV

I. **Antibacterial activity** (Well Diffusion Method)

II. Antioxidant activity

These experiments are carried out in Best treatments and Control

a. Hydrogen peroxide scavenging activity
b. Nitric oxide radical scavenging activity
c. Reducing power assay
d. DPPH radical scavenging activity

I. Phytochemical screening in selected plant leaves

1. Test for Alkaloids
2. Test for Anthroquinones
3. Test for Aminoacids
4. Test for Flavonoids
5. Test for Glycosides
6. Test for Phenols

7. Test for Steroids
8. Test for Saponins
9. Test for Tannins
10. Test for Terpenoids

II. **Estimation of mineral composition in selected plants leaves**

1. Sodium
2. Phosphorous
3. Potassium
4. Calcium
5. Iron
6. Magnesium
7. Zinc

RESULTS

PHASE I

Collection of agro-industrial wastes: The agro-industrial wastes of Cocoa shells and Jack fruit peel were collected from local villages of Kozhikode and Wayanad district in Kerala.

Collection of microorganism: The microorganism of *Pleurotus eous* and *Pleurotus florida* spawn were collected from Tamil Nadu Agricultural University (TNAU) Coimbatore and earthworms *Eudrilus eugeniae* Kinberg were obtained from Krishi Vigyan Kendra, Coimbatore.

Preparation of biocomposting units

The process of biocomposting consists of eight pits (1.6 ft. dimension and 5 sq.ft area).They were named as biocompost 1 (C1), biocompost 2 (C2), biocompost 3 (C3), biocompost 4 (C4), biocompost 5 (C5), biocompost 6 (C6), biocompost 7 (C7) and biocompost 8 (C8). The sundried cocoa shell waste was transferred to C1 pit. This process was repeated till the heap reaches a height above 1.5 meter and after 30 days vermicomposting (*Eudrilus eugeniae)* method is adopted. C2 pit was filled with cocoa shell waste and added 20 g of *Pleurotus eous*. It was allowed for decomposition for 30 days. Vermicomposting (*Eudrilus eugeniae)* process adopted. C3 pit was filled by cocoa shell. It was predigested using 20 g of *Pleurotus florida* spawn and then *Eudrilus eugeniae* process was adopted. C4 pit was filled with cocoa shell & added 10 g of *Pleurotus eous* + 10 g of

Pleurotus florida spawn. After 30 days transferred into the vermicomposting tray. The above same procedure was repeated in Jack fruit peel biocomposting units (C5, C6, C7 & C8).

The following treatments are used for each pit.

C - Control, no manure

C1- Raw CSW + *Eudrilus eugeniae* 5t/ha^{-1}(T_1)

C2- Raw CSW + 20 g *Pleurotus eous* + *Eudrilus eugeniae* 5t/ha-1(T_2)

C3- Raw CSW + 20 g *Pleurotus florida* + *Eudrilus eugeniae* 5t/ha-1(T_3)

C4 -Raw CSW +10 g *Pleurotus eous* +10 g *Pleurotus florida* + *Eudrilus eugeniae* 5t/ha-1(T_4)

C5- Raw Jack fruit peel + *Eudrilus eugeniae* 5t/ha^{-1}(T_5)

C6- Raw JFPW + 20 g *Pleurotus eous* + *Eudrilus eugeniae* 5t/ha^{-1}(T_6)

C7 - Raw JFPW + 20 g *Pleurotus florida* + *Eudrilus eugeniae* 5t/ha^{-1}(T_7)

C8- Raw JFPW + 10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1} (T_8)

Preparation of Vermicomposting Trays

After pre-decomposition, pre-digested cocoa shell and jack fruit peel was transferred to the eight plastic trays (40×20×20). Added around fifteen exotic earthworms (*Eudrilus eugeniae)* into above mentioned each biocomposting units. Water was sprinkled at regular intervals to maintain the moisture content of each tray. These experimental trays were kept in the room temperature undisturbed for 60 days. On the 90th day of composting, the samples were taken and sieved.

- **Microbial population:** During the biocomposting period (30, 60 & 90 days) total microbial population increased up to 30th to 60th day and then slightly declined on 60-90th day. On the 0-30th day, total bacterial, fungal and actinomycetes count was increased in C8 -Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5 t/ha^{-1} followed by C4 compared to control. On the 30-60th day, remarkable bacterial, fungal and actinomycetes count was obtained in C8 followed by C4 compared to control. During the 60-90th day of the experiment, total bacterial, fungal and actinomycetes population was slightly decreased. Maximum bacterial population was observed in C8 followed by C4 over control. The bacteria, fungi and actinomycetes count was conspicuously increased from 30th - 60th days and from 60th - 90th days it was reduced. The C8 and C4 biocompost increase the micronutrient contents which might have enhanced the total microbial population.

- **Physico-chemical composition of the raw and biocomposted Cocoa shell and Jack fruit peel waste**

The physicochemical parameters such as pH, electrical conductivity (millimhos cm-^{1}), nitrogen (%), phosphorus (%), potassium (%), calcium (%), magnesium (%), organic carbon (%), lignin (%), cellulose (%) and C:N ratio were analyzed in raw and biocomposted CSW and JFPW and control to assess the compost maturity. Among the eight different compost treatments, biocompost C8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5 t/ha^{-1} followed by C4-Raw CSW + 10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) was found to be efficient organic manure, because of the significant reduction in lignin, cellulose, EC, organic carbon and C: N ratio and remarkable increase in pH, nitrogen, potassium, calcium and magnesium followed by other treatments and control. The results concluded that the electrical conductivity (EC) reflects the salinity of organic amendments. High salt concentration may cause phytotoxicity problems and therefore EC is a good indicator of the suitability and safety of compost for agricultural purposes. The pH value of each biocompost is considered to be an indicator of the process of decomposition and stabilization. Lignin and cellulose can be recycled properly by biocomposting which serves as a good source of plant nutrients for sustainable crop productivity and fertility of the soil. The significant increase in total nitrogen content in the CSW and JFPW biocompost was not only due to the enhancement of nutrients but also due to the mineralization of organic matter by microorganisms. The increase in phosphorus content during microbial composting might be due to the composted CSW and JFPW which constitutes macro and micronutrients and provides decomposable organic matter by increasing soil aggregation and also releasing organic acids which in turn improves the phosphorus availability. The apparent increase in potassium content might be due to the higher mineralization rate as a result of enhanced microbial and enzyme activity. The C:N ratio reduction might be due to the loss of carbon as CO_2 due to the action of Earthworms and *Pleurotus* species.

- **Fourier transform-infrared (FT-IR) spectrum analysis**

FT-IR spectra analysis of raw and biocomposted Cocoa shell and Jack fruit peel waste showed some similar functional groups with different wavelengths of peaks. The results showed the presence of alcohol, alkene, alkane, halo compound, aromatic compound, esters, carboxylic acid, etc. FT-IR spectra showed the common absorption bands and functional groups found in before and after (biocomposted) samples. But intensities of functional groups were found to be varied from each other. The carboxylic

groups and aromatic compounds are absent in C4 &C8 that indicating the extensive decomposition of compost by the activity of a consortium of microorganisms. Various organic components are present in all spectra, significant differences can be observed in C8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}).

- **Scanning electron microscopy(SEM)**

SEM (MIRA3 TESCAN) was used to analyze surface transformations of raw and all biocomposted CSW and JFPW under different magnifications. All samples showed heterogeneous, porous, irregular, and cracked surfaces. After bioconversion, each biocomposting unit showed different structural modifications. The numerous texture change of biocomposted units confirmed the compost maturity. Major surface changes appear on C8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) followed by C4 (Raw CSW + 10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) due to the mineralization of organic matter.

PHASE II

- **Pot Culture Experiments:** One hundred eight pots were filled with 5 kg of red sandy loam soil. Eight biocompost treatments (T_1-T_8) were applied to the respective pots and control was maintained. A number of biometric observations, biochemical analysis, yield parameters and leghaemoglobin content were recorded at different stages during the growth of *Vigna unguiculata* (L.) Walp. *Vigna unguiculata* subsp.*sesquipedalis* (L.) Verdc., *Clitoria ternatea* L and *Amaranthus tricolor* L. as influenced by different Days After Sowing (DAS)

Collection of seeds

Seeds of *Vigna unguiculata* (L.) Walp were collected from the Department of Pulses, Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu. Seeds of *Vigna unguiculata* subsp.*sesquipedalis* (L.) Verdc and *Amaranthus tricolor* L from Krishi Bhavan, Kozhikode, Kerala.*Clitoria ternatea* L from Arya Vaidya Sala Herb Garden, Malapuram, kerala.

Biometric characters

Vigna unguiculata (L.) Walp. Var. Co (CP) 7): A significant increase in root length, shoot length and number of leaves, was recorded in T_8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) followed by T_4 (Raw CSW + 10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) on 25 DAS, 35 DAS and 45 DAS when compared with other treatments and control. Maximum numbers of nodules were

observed on 25-35 DAS in T_8 treatment. The number of nodules was decreased in all the treatments and control on 45 DAS. The numbers of flowers were more in T_8 followed by T_4 on 50 DAS. Fresh weight and dry weight was maximum from 25 to 45 DAS.

Vigna unguiculata subsp.*sesquipedalis* (L.) Verdc.Var.NS-621: Highest root length, shoot length and number of leaves were observed in T_8 and T_4 on 25, 50 and 75 DAS. The maximum number of nodules was recorded in T_8 &T_4 on 50 DAS. The maximum number of flowers/plants was noted in T_8 followed by T_4 on 65 DAS. Plant fresh weight and dry weight were significantly increased in T_8 from 25 to 75 DAS as compared to the control.

Clitoria ternatea L: The treatment T_8 showed an increase in root length, shoot length, number of leaves/plant, and number of branches/compound leaves on 30, 60 and 90 DAS. An appreciable increase in the number of flowers/plants was recorded in T_8 followed by T_4 on 90 DAS. The maximum fresh weight and dry weight content were registered in T_8 on 30, 60 and 90 DAS.

Amaranthus tricolor L.: The treatment T_8 noted the highest root length, shoot length, number of leaves/plant, plant fresh weight and dry weight on 25 and 35 DAS. Combined application of biocompost act as a catalytic agent in accelerating cell division and photo assimilation which boosts plant growth and also improved the plant building structures.

The application of Cocoa shell and Jack fruit peel biocompost prepared by using mushroom spawn *Pleurotus eous*, *Pleurotus florida* and *Eudrilus eugeniae* supplied readily available nitrogen and organic matter and also increased the microbial population. This might have improved the physico-chemical and biological properties of soil thus resulting in improved vegetative growth and photosynthesis.

- **Yield Characters**

It was observed from the present study number of pods/plant, length of the pod (cm), the weight of pod (g), number of seeds per pod, the weight of seeds per pod (g), pod fresh weight (g) and dry weight (g) content was significantly high in T_8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) and T_4 (Raw CSW + 10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) on 65 DAS in cowpea, 90 DAS in asparagus bean and 120 DAS in butterfly pea. Yield characters of red amaranths showed root length, shoot length, the number of leaves, fresh weight (g) and dry weight (g) of leaves were increased significantly in T_8 and T_4 on 50 DAS.

PHASE III

- **Biochemical Characters**

In leaves of Cowpea (25 to 35 DAS), asparagus bean (25 to 75 DAS), butterfly pea (30 to 90 DAS) and red amaranthus **(**25 to 35 DAS) showed maximum protein, carbohydrate, chlorophyll a, b and total chlorophyll in T_8 treatment. Similarly a maximum increase in protein and carbohydrate content in seeds of cowpea (65 DAS), asparagus bean (90 DAS), butterfly pea (120 DAS) and leaves of red amaranthus (50 DAS). The crude protein content in seeds was found to be maximum in T_8 followed by T_4 as compared to control in Cowpea on 65 DAS and asparagus bean on 90 DAS. The increase in total protein content might be due to the increase in the percentage of nitrogen and phosphorus present in the plants due to the application of CSW and JFPW biocompost. The decrease in total protein content might be attributed to its utilization for flower and pod/Fruit formation. The increase in carbohydrate contents might be due to the enormous amount of organic carbon present in the biocomposted CSW and JFPW which enhances the carbohydrate contents in the leaves of selected crop plants.

The significant increase in chlorophyll content in selected plants leaves were attributed to increased uptake of nitrogen, phosphorus, potassium and Mg, Fe and Cu which are readily available through Cocoa shell and Jack fruit peel waste biocompost are used in the formation of chlorophyll which is required for light harvesting and subsequent conversion into chemical energy via photo assimilation in leaves. The decline in chlorophyll content might be due to the breakdown of protein, ageing of the leaves and microbial cell lysis. Leghaemoglobin content in the root nodules of cowpea (35 DAS) & asparagus bean (50DAS) increased significantly in T_8 followed by T_4 as compared to the control (C). The application of biocompost might have improved the biological properties of the soil and increased the activities of beneficial microorganisms which resulted in the enhancement of the root nodules. The highest protein, carbohydrate and crude protein content due to the application of biocomposted CSW and JFPW compost enhanced the availability of phosphorus which might have favorably influenced the nitrogen uptake by plants and ultimately accumulated in seed as protein and carbohydrate.

- **Soil Analysis**

Pre harvest Soil Analysis: The results revealed that soil pH, electrical conductivity (millimhos cm^{-1}), available nitrogen (kg/ha), phosphorus (kg/ha) and potassium (kg/ha) were found to be more in T_8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida+ Eudrilus*

eugeniae 5 t/ha^{-1} followed by C_4-Raw CSW + 10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5t/ha^{-1}) treated soil as compared to control soil.

Post-harvest Soil Analysis: Maximum pH, electrical conductivity, available nitrogen (kg/ha), phosphorus (kg/ha) and potassium (kg/ha) were noted in T_8 biocompost as compared to control in cowpea, asparagus bean, butterfly pea and red amaranthus**.**

PHASE IV

- **Antibacterial activity and Antioxidant**

All the above experimental data were found to be statistically significant in all the biocompost (T_1-T_8) as compared to the control (C) treatment. Among the eight different types of biocompost, T_8 was found to be the more efficient organic manure as compared to other treatments. The treatment T_8 significantly enhanced the total microbial population, SEM, FTIR, biometric, yield, biochemical, and leghaemoglobin content and physico-chemical parameters of pre and post-harvest soil of cowpea, asparagus bean, butterfly pea and red amaranthus. For strengthening the above result, antibacterial and antioxidant activity was conducted with aqueous and methanol seed extracts of cowpea and asparagus bean and leaf extracts of butterfly pea and red amaranthus were grown under best treatment (T_8) and control (C).

- **Antibacterial activity:** Antibacterial activity was carried out in seeds of cowpea, asparagus bean and leaves of butterfly pea and red amaranthus. Seeds of (T_8-best treatment and C-control) aqueous and methanol extracts were examined against gram-positive (*Staphylococcus aureus*) and gram-negative (*Escherichia coli*) bacterial species. Both the extracts showed better antibacterial activity in four plants. Among the two extracts, methanolic extracts of red amaranthus showed the highest zone of inhibition against *Staphylococcus aureus* followed by the aqueous extract. The zones of inhibitions were moderately different from each other as compared to the standard antibiotics (Kanamycin).
- **Antioxidant activity**: The two plant seed samples and two plant leaves samples were analyzed for DPPH radical scavenging activity, hydrogen peroxide scavenging activity, nitric oxide radical scavenging activity and reducing power assay (free radical scavenging assays) in the aqueous and methanol extracts. By comparing the aqueous and methanol extracts of the four plants, promising antioxidant activity was shown in methanolic seed extracts of cowpea and asparagus bean and leaves extracts of butterfly pea and red amaranthus in T_8 (Raw JFPW+10 g *Pleurotus eous* + 10 g *Pleurotus florida*+ *Eudrilus eugeniae* 5 t/ha^{-1} treatment.

All above-mentioned experimental data will be statistically analyzed by using sigma stat 3.1 one-way and two-way ANOVA.

- **Phytochemical screening**

Medicinal plants are great interest today because of their vast source of phytochemicals having potent health-promoting activities. The present study investigated the phytochemical screening of the best treatment (T_8) grown red amaranthus and butterfly pea leaves. Aqueous, methanol and ethyl acetate leaves extract of red amaranthus and butterfly pea to contain various phytochemicals such as alkaloids, anthraquinones, amino acids, flavonoids, glycosides, phenols, steroids and saponins.

- **Estimation of mineral composition**

This study was carried out on cowpea, asparagus bean, red amaranthus and butterfly pea grown under best treatment (T_8) and control (C). The mineral composition of leaves of four plants showed the presence of microelements (iron, sodium) and macro elements (calcium, phosphorus, potassium & magnesium) was maximum in best treatment T_8 as compared to control.

Paper Publications

1) **Silpa, M**., & Vijayalakshmi, A. (2022). Efficiency of Biocomposted Agroindustrial Wastes and their Response in the Growth and Yield of *Vigna unguiculata* (L.) Walp. Agricultural Science Digest,42(3): 278-283.DOI: 10.18805/ag.D-5321.28.
2) **Silpa, M**. and Vijayalakshmi, A. (2022). Impact of Cocoa Shell and Jack Fruit Peel Waste Biocompost Influence on the Growth and Yield Attributes of Vigna unguiculata subsp. sesquipedalis (L.). Agricultural Science Digest. DOI: 10.18805/ag.D-5488.
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CONCLUSION

The goal of the current study is to expand the potential applications of agro-industrial wastes like Cocoa shells and Jack fruit peel wastes for raising crop productivity. Combined application of *Pleurotus eous, Pleurotus florida* (lignocellulolytic fungus) and Earthworms *Eudrilus eugeniae* Kinberg were discovered to be the primary decomposers of biocomposted cocoa shell and Jack fruit peel waste, making as effective organic manure. The present work is not only an alternate solution for the removal of agro-industrial waste of Cocoa shells and Jack fruit peel waste but minimizes the increased application of chemical fertilizers to crops and encourages organic farming for sustainable crop production. The process of biocomposting is a simple and low-capital investment technology. Biocomposted agro-industrial waste act as a soil conditioner to improve crop quality and increases productivity and reduce the risk of environmental pollution. The present research work confirmed that Cocoa shell and Jack fruit peel waste biocompost enhance the growth, yield and nutrient status in selected four plants and soil fertility. Hence, it concluded that Cocoa shell and Jack fruit peel biocompost could be effectively used as an organic fertilizer.

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